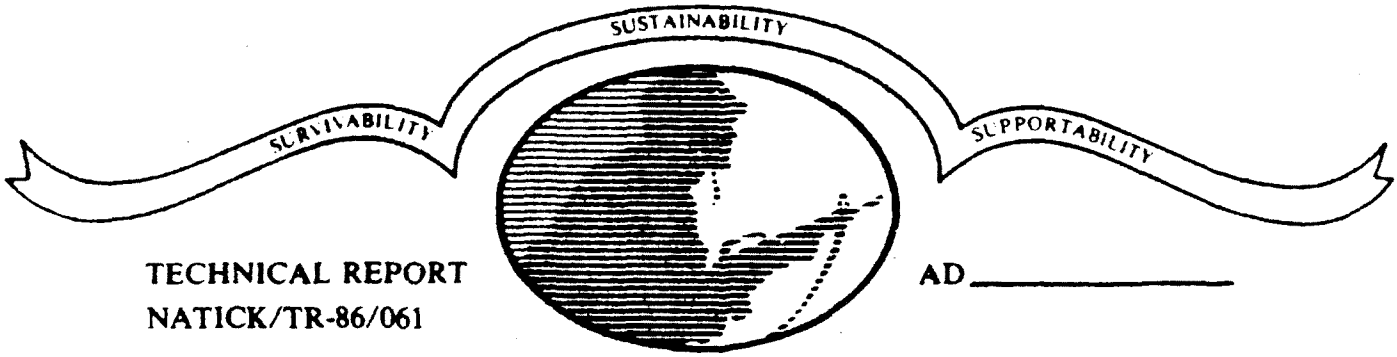

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STABILITY OF VITAMINS C, B_1, B_2 AND B_6 IN FORTIFIED BEEF STEW

BY

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A study was conducted to determine the stability of ascorbic acid, thiamin, riboflavin and pyridoxine (vitamins C, B_1, B_2 and B_6, respectively) in fortified and unfortified beef stew before and after thermoprocessing in a 105-fluid ounce flat can (Tray Pack) as well as after simulated preparation for field feeding to troops. The results indicate that only thiamin underwent considerable degradation during thermal processing to a minimum F_o of 6.0. When reheated to and held at 85°C, the rate of thiamin destruction in fortified beef stew was about 2% per hour. Regression analysis of the data on thiamin destruction in Tray Packs at four different temperatures has enabled the prediction of thiamin loss under conditions other than those examined. Fortification of beef stew with vitamins is feasible from a nutritional standpoint and the addition of ascorbic acid may even enhance its shelf life. Ascorbic acid retention during processing was surprisingly high (82%) in fortified beef stew. Furthermore, heating fortified beef stew in unopened trays for 16 h at 85°C caused no change in ascorbic acid level. Military field feeding practices resulted in little or no change in the vitamin content of fortified beef stew packed in trays.

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PREFACE

Nutrient fortification is crucial for military rations where micronutrients are destroyed during long term storage or are initially present at less than the prescribed standard level established by the Surgeon General in AR 40-25. The lability of vitamins such as thiamin and ascorbic acid during processing makes it important that all possible fortification avenues are explored.

There are very few vitamin retention studies in the literature where a substantial level of vitamins have been added to thermoprocessed foods. In the present study (project No. 1L16AH99BA028), the feasibility of fortification of tray packed beef stew with vitamins B_1, B_2, B_6 and C at twice the recommended allowance/ration/day was explored. In addition, the military field feeding practices were simulated and exaggerated to document any further changes in nutrient content. The collection of a large amount of data on vitamin losses under defined time-temperature conditions has enabled the prediction of vitamin losses at various other temperature-time conditions that may be occasionally encountered under field operation. This study, it is therefore anticipated would serve as a useful guide for field feeding practices of thermoprocessed tray pack beef stew and other similar products.

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STABILITY OF VITAMINS C, B_1, B_2 AND B_6 IN FORTIFIED BEEF STEW

INTRODUCTION

Combat field feeding systems for the Army must provide high quality hot meals and increased efficiency in food service consistent with having troops widely dispersed.[1] For this reason, a system concept has been developed that maximizes the use of an improved food technology for producing heat-sterilized, fully prepared, shelf-stable foods. These foods, labeled Tray Packs, can be distributed anywhere combat troops are located.

The Tray Pack, the basis for T Rations, consists of a variety of Tray Pack entrees, vegetable, starch, salad, and dessert items that have been heat-processed in rectangular, multiserving, half-sized steam table, metal cans. It is anticipated that use of Tray Packs in the T Ration will increase the Army's capability for providing high quality, nutritionally adequate, hot meals to its troops in the field while significantly reducing the manpower, fuel, and water requirements of the present system. The flat tray configuration gives greater quality potential for its heat processed contents than does the round can, because it allows significant reduction of the processing time to attain sterility. Additionally, the Tray Pack foods are ready to heat and serve in a container that funtions as a heating and serving vessel. These foods were consumed in Lebanon and found to be highly acceptable.

For this reason, the U.S. Army Natick Research, Development and Engineering Center conducted laboratory tests to determine the effects of processing, reheating, and holding on the vitamin content of beef stew. Due to the low concentration of vitamins in beef stew, the study included Tray Pack beef stew to which vitamins were added prior to thermoprocessing. The results were to provide a basis for making recommendations (1) to improve products through suitable fortification, (2) to improve the method of thermoprocessing, and/or (3) to propose limitations on "hot" holding periods for serving purposes.

To determine vitamin loss due to the thermoprocessing, the product was analyzed prior to and after retorting. In addition, expected and exaggerated field preparation conditions were simulated to ascertain losses due to preparation for serving. The vitamins selected for study were ascorbic acid (vitamin C), thiamin hydrochloride (vitamin B_1), riboflavin monophosphate (vitamin B_2), and pyridoxine hydrochloride (vitamin B_6).

MATERIALS AND METHODS

Frozen, whole round of beef (USDA inspected) was boned, trimmed and diced for use to prepare Tray Pack beef stew. In addition to the beef, frozen crinkle-cut carrots, dehydro-frozen white potatoes, and gravy were included in accordance with Tray Pack specification for beef stew (Interim Specification, 1984).[2] In the case of fortification, the vitamins were added at twice the recommended allowance[3]/ration/day to the gravy at the last stage of its preparation.

A half-sized steam table tray, capable of holding 105-fluid ounces, was used to contain the product. The tray was two inches deep, made of chrome/chrome-oxide coated steel with a double-seam closure lid sealed to the body of the tray to form a positive hermetic seal.[4] Most Tray Packs were equipped with at least one thermocouple prior to filling. Immediately after filling, the trays were vacuum-sealed (10 inches) and loaded into the retort for processing as rapidly as possible. Each thermocouple was connected to a data recorder (Digistrip III) to register the temperature within the product throughout the processing period.

Twenty Tray Packs were loaded onto the middle two shelves of the retort to minimize anticipated tray-to-tray temperature variations during processing. The retort was filled with water, heated to an operating temperature of 121°C, and kept at that temperature until a minimum F_o value of 6.0, commercial sterility, was attained. After processing, trays were held at room temperature until subjected to various treatments before conducting nutrient analyses. The subsequent treatment to simulate preparation for field serving is outlined in Table 1.

TABLE 1. Tray Pack Beef Stew Test Plan for Heat-Hold Study.

UNFORTIFIED	*FORTIFIED	PRODUCT Temp °C	WITHDRAWAL PERIODS Hours
X	X	85	0,1,2,4,8,16,24
	X	77	0,2,4,8,16,24,32
	X	74	0,2,6,10,18,36
	X	63	0,4,8,16,24,40
X	X	27	0
X	X	Frozen	0

*Fortification Level Per Meal: 2 Times RDA of Vitamins C, B_1, B_2 and B_6

To prepare for field serving, Tray Packs were heated in a boiling water bath to either 85, 77, 74, or 63°C, removed from the water bath to an electric oven, and held unopened at the temperature to which they had been heated for various time intervals, 0 to 40 hours. The tray and oven temperatures were monitored and recorded. Immediately after the heat-hold treatment, the product was blast frozen, and held frozen until duplicate nutrient analyses were made on two replicate trays of each treatment. Vitamins analyses were performed according to the procedure described in Method of Vitamin Assay.[5]

RESULTS AND DISCUSSION

The effect of processing on the vitamin content of fortified and unfortified beef stew is shown in Table 2. As expected, the concentration of vitamins under test was low in the unfortified beef stew, and an accurate assessment of their stability could not be made. During the processing of fortified beef stew, there was no less than 82% retention of ascorbic acid, riboflavin, and pyridoxine. However, there was only 47% retention of thiamin in the fortified beef stew. The excellent preservation of ascorbic acid in fortified beef stew was undoubtedly due to the limited head space and reduced procesing time for Tray Packs compared with conventional cylindrical cans as well as due to the high level of fortification used in this study. In view of the well known antioxidant synergistic effect of ascorbic acid, it is quite possible that the level of fortification used in this study may well enhance the shelf life of Tray Pack products.

TABLE 2. Effects of Processing on Vitamin Content of Beef Stew.

VITAMINS	LEVEL	BEEF STEW RAW FROZEN	BEEF STEW RETORTED UNHEATED	RETENTION
		mg/100g		%
C	0	*TR	TR	
	**2x	39.2	32.3	82
B_1	0	0.057	0.020	35
	2x	1.46	0.690	47
B_2	0	0.112	0.120	107
	2x	1.69	1.74	103
B_6	0	0.10	0.06	60
	2x	2.5	2.25	90

*Traces
**Vitamins Added at the Level of 2 Times RDA Per Meal

Upon reheating the fortified product in the unopened Tray Pack (Table 3) to various temperatures prior to holding the product at the temperature to which it was heated, there was no change in vitamin content except for pyridoxine, which decreased by 25 percent. This loss was unexpected since pyridoxine was not affected by the processing and is considered stable to heat. The pyridoxine data obtained with the trays heated and held for prolonged time (Table 4) would appear to suggest this loss observed here in pyridoxine (Table 3) was most likely due to replicate variation rather than due to heating of the Tray Packs to temperature.

Holding fortified beef stew Tray Packs unopened in an oven at 63°C from 0 to 40 hours resulted in no significant decrease in the content of vitamins B_2, B_6 and C (Table 4). However, thiamin decreased significantly upon heating for 40 h at 63°C. After reheating to 74 or 77°C and holding for up to 36 or 24 hours, respectively, no striking changes in the contents of vitamin C, B_2, or B_6 were evident. Thiamin loss was negligible when the product was reheated and held for 6 hours at 74 and 77°C. However, there was a 25% reduction in thiamin at both 74 and 77°C after heating for 36 and 24 hours, respectively. Reheating and holding the product at 85°C for 8 and 24 hours resulted in 14 and 47% loss of thiamin, respectively. No appreciable change in ascorbic acid, riboflavin, or pyridoxine occurred under these conditions. Consequently, holding the Tray Pack of fortified beef stew for 8 hours at 85°C is not considered to be a significant impairment to its vitamin content. At any rate, such an event is not typical of military field feeding practice.

TABLE 3. Effect of* Reheating to Temperature of Thermoprocessed Tray Pack Beef Stew on Vitamin Content

°C	REHEATED mg/100g	RETENTION %
	ASCORBIC ACID	
**27	32.3	
63	32.2	100
74	35.8	111
77	33.8	105
85	31.6	98
	THIAMIN	
27	0.690	
63	0.740	107
74	0.680	99
77	0.676	98
85	0.672	97
	RIBOFLAVIN	
27	1.74	
63	1.64	94
74	1.62	93
77	1.56	90
85	1.70	98
	PYRIDOXINE	
**27	2.25	
63	2.52	112
74	1.96	87
77	2.18	97
85	1.72	76

*Fortified
**Unheated, Control

TABLE 4. Vitamin Retention* of Beef Stew Tray Pack (heated and held).

°C	HOURS	VITAMINS			
		C	B_1	B_2	B_6
63	4	96	95	98	97
	8	102	93	101	98
	16	99	91	99	96
	24	94	90	98	96
	40	94	84	96	95
74	2	99	99a	100	99a
	6	99	96ab	99	98ab
	10	97	93bc	100	99a
	18	102	88c	100	102a
	36	99	75d	99	94b
77	2	104	102a	99	98
	4	102	100a	100	99
	8	101	93a	104	96
	16	96	84c	107	100
	24	96	76d	104	98
85	1	108	103a	93	100a
	2	100	97b	98	103a
	4	103	91c	94	103a
	8	94	86d	89	101a
	16	95	63e	91	98a
	24	93	53f	96	91b

*Percentages bearing the same letter are not significantly different (p 0.05) from each other.

Regression analysis of data of vitamin B_1 destruction in the fortified beef stew Tray Pack at four different temperatures was undertaken to be able to predict losses under those conditions. In Figure 1, the log of the percent of thiamin remaining is plotted against time. It is clearly evident that degradation of thiamin in the product increases with time and temperature. Linear regression plots for each of these curves are shown in Figure 2. The regression coefficients ranging from 0.95 to 1.0 indicated a very good fit. An Arrhenius plot describing the temperature-rate constant relationship (Figure 3) was obtained. The resulting regression plot suggests that one can reasonably predict vitamin losses at temperatures other than those utilized in this study. From this plot, an activation energy for thiamin degradation of 18.2 kcal/mole was obtained. The rate of thiamin destruction was calculated to be about 2% per hour at 85°C.

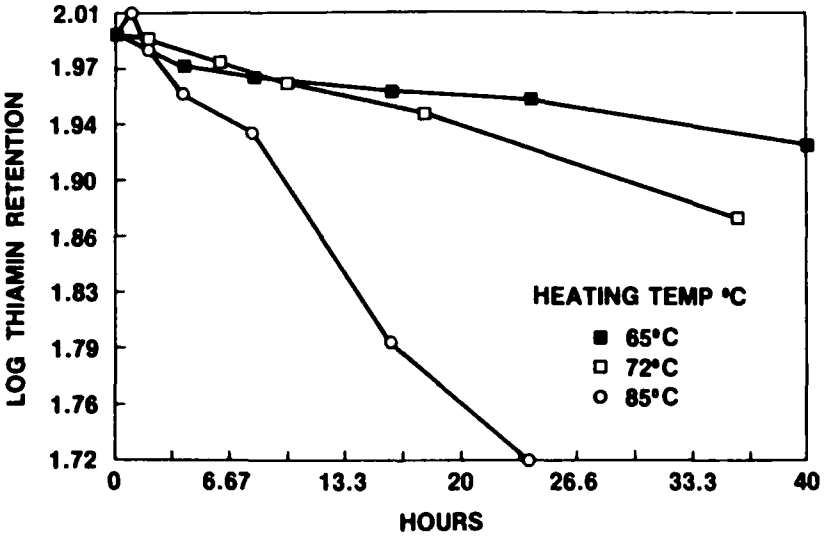

Figure 1. Fortified Beef Stew Tray Pack: Thiamin Degradation

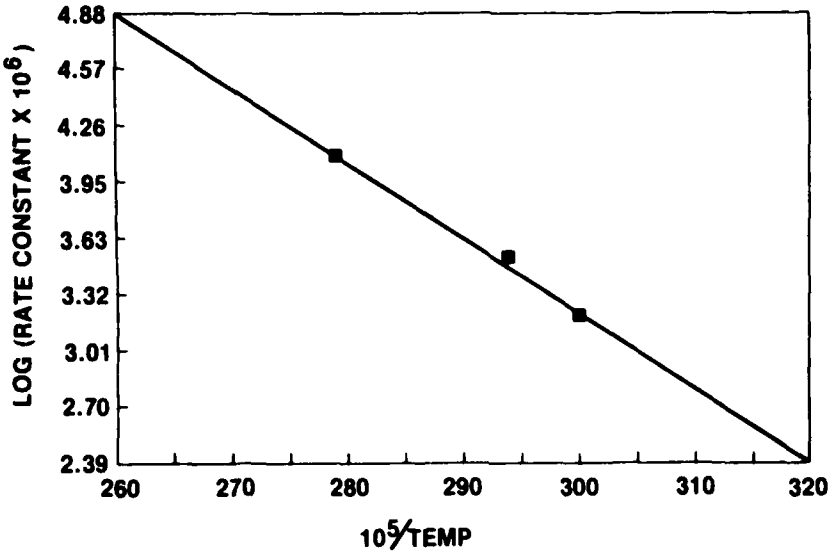

Figure 2. Fortified Beef Stew Tray Pack: Thiamin Degradation Regression Plot

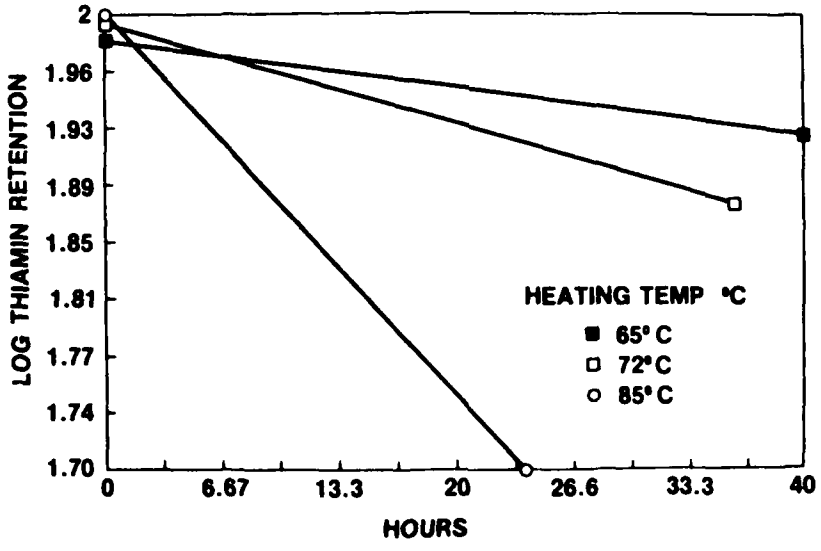

Figure 3. Fortified Beef Stew Tray Pack: Temperature-Rate Constant Relationship for Thiamin — Regression Plot with Data Points

CONCLUSIONS

The study of the effect of thermal processing in a flat can on the stability of specific nutrients in vitamin fortified and unfortified beef stew show that:

(1) In fortified beef stew, no significant loss occurred in vitamins C, B_2, or B_6 during commercial sterilization of the product; however, there was a 53% decrease in thiamin content.

(2) Additional reheating of fortified beef stew to simulate and exaggerate military field feeding practices resulted in little change in vitamin C, B_1, or B_2.

(3) The excellent preservation of ascorbic acid in fortified beef stew is attributable to the improved thermoprocessing technology. It is possible that ascorbic acid fortification to Tray Pack foods may enhance their shelf life.

(4) After holding fortified beef stew for various time intervals at 85°C, there was significant loss of about 2% per hour of thiamin, but there were no major changes in the remaining nutrients under test.

(5) Regression analyses of the data on vitamin B_1 in fortified beef stew Tray Pack has enabled the predication of thiamin loss under conditions other than those examined. The energy of activation for thiamin degradation in reheated Tray Packs was estimated to be 18 kcal/mole.

(6) Fortification of beef stew Tray Pack with vitamins is feasible, and treatment of the product according to military field feeding practices is considered favorable to its nutrient content.

RECOMMENDATIONS

(1) Serious consideration should be given to vitamin fortification of Tray Pack items where they do not provide significant contribution to the Military Recommended Daily Allowance of such nutrients.

(2) A time-temperature nomogram should be prepared for each micronutrient to predict probable losses under various field situations.

(3) Acceptance data should be collected on fortified Tray Pack items to establish the feasibility of incorporation into the system.

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